The effectiveness of osteopathic treatment in elderly people

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Introduction

Global birth rates are declining while lifespans are increasing, leading to rapidly aging populations, particularly in Europe and Asia. The proportion of people over 65 is growing and will continue to do so for the next two decades, with a sharp increase in those over 85 expected by 2050. Thailand is among the countries aging most rapidly, projected to become a "super-aged society" within the next decade.

Aging is a complex, irreversible process characterized by declining tissue and cell function and increased risk of age-related diseases (neurodegenerative, cardiovascular, metabolic, musculoskeletal, and immune system diseases). Managing the health of older adults requires a holistic approach considering psychological, social, functional, and physiological factors. Osteopathy, with its holistic principles emphasizing the mind-body-spirit connection, self-healing capabilities, and the structure-function relationship, is well-suited to address the complex health needs of the aging population. 1,2,3,4,5

Aging (or Elderly)

The World Health Organization (WHO) defines senility as age 60+, while American classifications typically use 65 as the cutoff. Gerontologists further subdivide older adults into younger-old (60-74), older-old (75-85), and oldest-old (85+). Clinicians often distinguish between older patients under and over 80 due to a significant decline in physical and mental capabilities beyond that age.

Aging, an inevitable process, is commonly measured chronologically, with "elderly" often defined as 65+. Biologically, aging stems from the accumulation of molecular and cellular damage, leading to decreased physical and mental capacity, increased disease risk, and ultimately death. Common age-related conditions include hearing loss, cataracts, back/neck pain, osteoarthritis, COPD, diabetes, depression, and dementia. Multiple conditions are common in older adults, along with geriatric syndromes (frailty, incontinence, falls, delirium, pressure ulcers) resulting from multiple underlying factors.6,7

Physiological changes in elderly

Aging brings about physiological changes across all organ systems. The cardiovascular system experiences decreased cardiac output, increased blood pressure, and arteriosclerosis. Lung function declines, with impaired gas exchange, reduced vital capacity, and slower expiratory flow rates. Kidney function decreases (creatinine clearance), though serum creatinine levels remain relatively stable due to reduced creatinine production. The gastrointestinal system shows altered motility, atrophic gastritis, and altered hepatic drug metabolism. Blood glucose levels progressively rise with age. Osteoporosis is common due to bone mass decline after age 40. The skin's epidermis atrophies, and collagen/elastin changes lead to loss of tone and elasticity. Lean body mass decreases due to muscle cell loss and atrophy. Degenerative joint changes, combined with muscle loss, impair locomotion. These changes have significant clinical implications, affecting

metabolism, drug responses (requiring altered dosages), and necessitating preventive programs of diet and exercise to delay or reverse some age-related decline.8

Cardiovascular system

Structural changes include a mild increase in heart weight (left ventricular hypertrophy), alterations in cardiac shape (aorta shift, septal bulge, outflow tract narrowing), increased cardiomyocyte size but reduced number, and increased collagen deposition. The collagen-to-myocyte ratio, however, remains unchanged. Partial degeneration of the cardiac sympathetic nerve supply is also observed.

Functionally, resting systolic function (ejection fraction, stroke volume, cardiac output) is largely preserved. However, diastolic function is significantly impaired, showing reduced early diastolic filling compensated by increased end-diastolic filling, resulting in a lower E/A ratio. β-adrenergic responsiveness is blunted, leading to reduced heart rate and contractility increases in response to catecholamines or exercise. The aging heart compensates by utilizing the Frank-Starling mechanism, increasing end-diastolic and end-systolic volumes to maintain cardiac output during exercise. Peak cardiac output during maximal exertion is reduced by 20-30% in the elderly compared to young adults, mainly due to decreased tachycardia. The aging heart's exercise response resembles that of a younger heart under β-blocker treatment. Lusitropic function is also impaired, with delayed relaxation due to prolonged contraction duration (from prolonged action potential and active state). Inotropic responses to digitalis are reduced, but calcium ion responses are preserved, suggesting a problem in signaling pathways rather than the contractile machinery. These changes may contribute to diastolic heart failure in older adults.

Aging significantly impacts the vasculature, leading to both structural and functional changes. Structurally, large arteries become elongated, tortuous, and have a thickened wall, primarily in the intima and media. This thickening involves increased collagen, elastin, and proteoglycans, along with an infiltration of vascular smooth muscle cells, leukocytes, and macrophages. Inflammatory substances like adhesion molecules, matrix metalloproteinases, and cytokines also become more abundant.

Functionally, aging arteries exhibit impaired distensibility, leading to increased pulse wave velocity and reduced cushioning function. Endothelial permeability increases, while the vasodilator response to acetylcholine (mediated by nitric oxide) is reduced. Responses to both α2-adrenoceptor and β-receptor agonists are also attenuated.

The similarities between age-related vascular changes and atherosclerosis are striking, leading to the suggestion that aging might be a prodromal stage of atherosclerosis, or vice versa. However, age-related changes can exist without progressing to overt disease, suggesting distinct origins. Future research will focus on identifying the genetic and molecular mechanisms governing the transition from benign age-related changes to pathological atherosclerosis.

Systemically, age-related vascular changes cause increased peripheral resistance and systolic and pulse pressure. This elevated pressure further stimulates vessel wall hypertrophy and stiffness, creating a self-perpetuating vicious cycle.

the homeostatic and clinical implications of age-related cardiovascular changes ;

1. Diastolic Heart Failure: Age-related impairment of left ventricular diastolic function is a significant risk factor for diastolic heart failure, which is highly prevalent in older adults.

2. Increased Blood Pressure: The combined effects of increased pulse wave velocity and prolonged ejection time lead to the summation of arterial waves, contributing to elevated systolic and pulse pressure. This increases the risk of vascular damage, cardiac workload, left ventricular hypertrophy, further arterial stiffening, cerebrovascular events, and renal dysfunction.

3. Coronary Artery Disease Risk: Altered endothelial function in aging coronary arteries is a risk factor for coronary artery disease. Increased carotid intima-media thickness (CIMT) is a predictor of cardiovascular events.

4. Blood Pressure Instability: Slowed arterial baroreceptor responses in older adults impair blood pressure regulation, increasing the risk of postural or postprandial hypotension and blood pressure variability. Reduced heart rate variability is also observed.

5. Arrhythmia Risk: Impaired baroreceptor control of heart rate may increase the risk of life-threatening arrhythmias. Regular exercise and slow breathing techniques may offer protective effects.

6. Electrolyte and Fluid Imbalance: Impaired cardiopulmonary reflex can lead to altered electrolyte and fluid homeostasis, increasing the risk of dehydration. This necessitates caution in prescribing diuretics for elderly patients.9

Respiratory system

Aging causes structural changes in the respiratory system, primarily affecting the thoracic cage and reducing chest wall compliance. This is due to age-related osteoporosis leading to decreased thoracic vertebral height, rib cage calcification, and kyphosis. These changes restrict thoracic expansion during inspiration, mechanically disadvantaging the diaphragm and impairing effective contraction. Studies show that while lung compliance remains relatively stable with age, chest wall compliance decreases, resulting in increased residual volume (RV) and incomplete lung emptying.

Aging significantly impacts respiratory muscle function, particularly diaphragmatic strength. While direct measurement of diaphragmatic strength is challenging, studies using indirect measures like maximum inspiratory pressure (MIP), transdiaphragmatic pressure (Pdi), and maximum voluntary ventilation (MVV) reveal age-related declines. MIP decreases significantly with age, more so in men than women. Pdi also shows a substantial reduction in older adults compared to younger adults, although the magnitude of decline varies depending on measurement techniques. MVV also declines with age. These reductions are likely due to muscle atrophy and a decrease in fast-twitch muscle fibers. The resulting decline in diaphragmatic strength may increase the risk of diaphragmatic fatigue and ventilatory failure, especially under increased ventilatory demands.

Senile hyperinflation of the lungs is a common age-related change, though its exact cause (destruction of lung parenchyma or loss of supporting structures) is unclear. Studies show an increase in airspace size with age, linked to homogeneous degeneration of elastic fibers around alveolar ducts starting around age 50. This reduction in supporting tissue leads to premature closure

of small airways during breathing, potentially causing air trapping and hyperinflation, a condition sometimes referred to as "senile emphysema."

Aging leads to several immunologic changes in the respiratory system. Bronchoalveolar lavage (BAL) fluid from older adults shows a higher proportion of neutrophils and a lower percentage of macrophages compared to younger adults. Levels of immunoglobulins IgA and IgM are increased in BAL fluid with age, and the CD4+/CD8+ lymphocyte ratio also increases, suggesting a primed T-cell response from repeated antigen exposure in the lower respiratory tract. Alveolar macrophages in older adults also exhibit increased superoxide anion release in response to stimuli. These changes likely reflect a combination of repeated antigen exposure and a decline in the down-regulatory response to antigens with age. The resulting chronic, low-grade inflammation can damage the lung matrix, leading to alveolar unit loss and impaired gas exchange.

Epithelial lining fluid (ELF), rich in antioxidants that protect against oxidative injury, also undergoes age-related changes. Studies show a reduction in ELF antioxidant levels (superoxide dismutase, catalase, metal-binding proteins, glutathione, vitamins C and E) after exposure to environmental toxins like ozone, nitrous oxide, and particulate matter. These age-related changes in ELF composition increase the susceptibility of older individuals to the harmful effects of environmental toxins. The full clinical implications of these age-related immune dysregulations remain to be determined.10

Renal system

Aging causes widespread molecular and cellular damage, with noticeable changes appearing after age 30. Kidney health is a strong predictor of longevity, and chronic kidney disease is a major cause of death globally. Early detection of kidney dysfunction is crucial due to the kidneys' susceptibility to aging. Maintaining overall health, through measures like a proper diet and exercise, is key to mitigating age-related kidney decline.

The kidneys filter blood, remove waste, regulate essential compounds, and produce hormones like erythropoietin, renin, and calcitriol. Prolonged oxidative stress can impair kidney function and disrupt homeostasis. Aging affects the kidneys by decreasing the number of nephrons and glomerular filtration rate (GFR). This decline is influenced by both modifiable (e.g., hypertension, diabetes, obesity) and non-modifiable factors (e.g., sex, race). Most healthy elderly individuals experience only minimal kidney disease progression, with comorbidities significantly impacting the rate of decline.

GFR, a primary measure of kidney function, declines linearly after age 30, decreasing by about 46% by age 90 in healthy individuals. This decline is attributed to nephron loss, glomerular sclerosis and atrophy, and changes in renal hemodynamics. Decreased protein intake, common among the elderly, may also contribute.11

Macroscopic Changes: Aging kidneys exhibit a roughened surface and an increased number and size of simple renal cysts. These cysts, while generally benign, have been linked to hypertension, reduced kidney size, and functional decline, potentially indicating early damage. Kidney volume significantly decreases with age, approximately 16 cm^3 per decade after age 60, with a greater decline in cortical volume than medullary volume after age 50. Overall, kidney mass decreases by roughly 20-25% between ages 30 and 80.

Microscopic Changes: Histological changes include nephrosclerosis (characterized by nephron loss, hypertrophy of remaining nephrons, arteriosclerosis, global glomerulosclerosis, tubular atrophy, and interstitial fibrosis), glomerular basement membrane thickening, mesangial broadening, and increased extracellular matrix accumulation. Nephron loss due to glomerulosclerosis is substantial, with an estimated 6,000-6,500 nephrons lost annually after age 30. However, the extent of glomerulosclerosis may underestimate the actual nephron loss. 12

Clinical Significance:

- Elderly patients are at increased risk of dehydration, AKI (acute kidney injury), hyperkalemia, and cardiovascular complications. Careful medication administration (reduced doses of hydrosoluble drugs) is crucial due to decreased GFR.

- While decreased GFR is common with age, it's not solely diagnostic of CKD (chronic kidney disease). Diagnosis requires considering GFR, albuminuria, and other urinary changes. Increased negative events are not solely linked to decreased GFR. Albuminuria is a significant marker of cardiovascular risk. Cystatin C is also useful in assessing cardiovascular involvement. Cardiovascular comorbidities significantly increase mortality in CKD patients.

- Hypertension is prevalent in elderly CKD patients, often exacerbated by mineral and bone disorders and vascular calcifications. High uric acid levels further increase blood pressure and cardiovascular risk.

Patient Management:

- ACE inhibitors (ACEI) and angiotensin receptor blockers (ARB) are first-line treatments for hypertension in elderly CKD patients. Blood pressure targets are individualized, aiming to avoid orthostatic hypotension and GFR decline. Close monitoring is essential to detect treatment-related creatinine increases. In chronic hemodialysis patients, ACEI/ARB may be combined with beta-blockers or calcium channel blockers.

- Age significantly influences CKD progression. In very old patients, CKD progression to end-stage is less likely due to aging alone; death may occur before significant progression. However, some elderly patients do progress to end-stage CKD, necessitating careful monitoring and management.

- Decisions regarding renal replacement therapy (RRT) in geriatric patients require a comprehensive assessment: treatment modality (hemodialysis, peritoneal dialysis, transplant), prognosis, vascular status, patient compliance, and quality of life. In some cases, conservative treatment may be preferred. While RRT survival is shorter in elderly patients compared to younger patients, it's still better than conservative treatment alone.13

Digestive system

Aging significantly impacts chewing and swallowing. Decreased bite force, reduced mandibular reflexes, fewer oral sensory receptors (leading to increased sensory thresholds), and decreased saliva production are common age-related changes. These changes affect bolus formation, the process of creating a cohesive mass of chewed food ready for swallowing. In individuals with good

oral health, these changes lead to only minor masticatory adaptations, such as an increased number of chewing cycles. However, individuals with poor oral health, including significant tooth loss or saliva deficiency, experience more significant impairments. Insufficient food breakdown due to poor dentition and reduced saliva leads to difficulty swallowing (dysphagia), aspiration, impaired nutrient dissolution, and an increased risk of malnutrition. Elderly individuals with poor oral health often modify their diets to accommodate their limitations, often opting for soft, less nutritious foods. There's also a suggested link between masticatory deficiency and cognitive dysfunction, although further research is needed to establish a causal relationship. Comprehensive oral health assessments, including the number of functional teeth, xerostomia perception, and GOHAI scores, should be incorporated into nutritional studies of the elderly to better identify those at risk of malnutrition.

Aging affects food transit time and motility throughout the gastrointestinal tract, although the extent and consistency of these effects are not fully understood due to conflicting research findings and variations in the health status of elderly populations. Gastric emptying time may be prolonged, particularly in frail elderly individuals, while the impact on small bowel transit time is less clear, with some studies showing minimal changes. Colonic transit time may also be increased in older adults, although this could be influenced by factors such as physical inactivity and diet. Constipation, while prevalent in older age, doesn't appear to be a direct consequence of normal aging but rather a result of various factors including diet, activity levels, and underlying health conditions. Regarding motility regulation, age-related changes in smooth muscle function (impaired signal transduction and calcium signaling), enteric nervous system (neuronal loss and degeneration in the myenteric plexus, particularly cholinergic neurons), and interstitial cells of Cajal (reduced density and volume) may contribute to impaired gut motility. The exact mechanisms and extent of these age-related changes in motility require further investigation. The use of advanced technologies like wireless motility capsules may improve our understanding of these processes.

Endogenous Enzyme Digestion:

• Saliva: While salivary flow significantly decreases with age (approximately 50%), daily alpha-amylase output paradoxically increases. Lipolytic activity in saliva remains weak.

Stomach: Gastric acid secretion shows conflicting results, with some studies showing no change and others showing an increase. However, Helicobacter pylori* infection and atrophic gastritis (both more prevalent with age) are associated with decreased secretion. Pepsin secretion declines significantly after age 70.

• Pancreas: Studies in both animals and humans demonstrate a decrease in pancreatic exocrine secretions (bicarbonate and enzymes like lipase, chymotrypsin, and amylase) with age. This is due to reduced volume and enzyme concentration. Pancreatic atrophy and degeneration are also observed. However, some studies with rigorously healthy elderly individuals show no significant impairment, suggesting the decline may not always cause maldigestion. Endocrine pancreatic function (beta-cell mass) is relatively well-preserved in non-diabetics, although insulin resistance increases with age.

- Bile: Bile secretion itself isn't directly involved in digestion. While bile volume and total bile acid secretion aren't significantly affected by age, bile acid reabsorption might be impaired.

Microbial Digestion:

• Aging is associated with reduced biodiversity and stability of the gut microbiota. While the impact on the dominant Firmicutes and Bacteroidetes is debated, there's an increase in facultative anaerobes (including pro-inflammatory bacteria) and potentially no change in health-promoting bacteria like Bifidobacteria.

• The age-related changes in microbiota correlate with frailty, co-morbidity, nutritional status, and inflammation. Functional metagenomics suggests a loss of genes for short-chain fatty acid production, decreased saccharolytic potential, and increased proteolytic potential in the aging gut microbiome. Colonic fermentation is also reduced in elderly individuals.

Aging leads to demonstrable changes in digestive enzyme production and gut microbiota composition. While some changes, such as decreased pancreatic enzyme secretion, are consistently observed, the clinical significance of these changes in healthy individuals is not always clear, with some studies showing no significant impact on digestion in very healthy older adults. The impact of age-related changes on overall digestive function warrants further investigation.

Aging affects the gut wall in several ways. While the architecture of the intestinal epithelium (villus height and crypt depth) remains largely unchanged, there's evidence of increased cell proliferation balanced by increased apoptosis, maintaining the absorptive surface area. This increased proliferation is associated with increased EGFR activation. Intestinal permeability appears largely unaffected in the small intestine but may increase in the colon. Lipid absorption (per unit of mucosal surface area) shows conflicting results, with some studies showing no change, while cholesterol absorption may increase. Sugar absorption is affected, with fructose uptake increasing and glucose uptake decreasing. The impact on amino acid and peptide transport is unclear. Calcium absorption decreases due to reduced expression of key proteins (calbindin-D9k, TRPV6, PMCA1b) and reduced 1,25(OH)2D3 responsiveness. The effect of aging on iron absorption is not well documented. The intestinal barrier and immune system show age-related decline ("immunosenescence"), with reduced production of IgA, decreased oral tolerance, and reduced numbers of M cells and dendritic cells in Peyer's patches. Regarding endocrine function, gastrin levels are largely unaffected except in H. pylori infection. CCK response is reduced postprandially, while ghrelin response is inconsistent. PYY levels are generally unchanged. GLP1 and GIP responses are mostly unaltered in non-diabetics, but one study showed increased GIP and GLP1 in postmenopausal women. The effect of aging on GLP2 is unknown.

Aging impacts nutrient bioavailability in several ways. While protein digestion appears sufficient in healthy elderly individuals, older rodents show reduced adaptability to nutritional stress. Data on human protein digestibility in the elderly is scarce. The impact of reduced amylase and lipase secretion on starch and lipid digestion in humans is unknown, and the bioavailability of essential fatty acids (EFAs) with age is unclear. Vitamin B12 deficiency is common in the elderly due to malabsorption (often related to decreased pepsin/acid secretion, intrinsic factor deficiency, or defects in the cobalamin uptake system) and inadequate dietary intake. The effect of aging on fat-soluble vitamin bioavailability isn't well understood. Calcium absorption decreases due to reduced 1,25(OH)2D3 responsiveness and decreased expression of key transport proteins. The impact of aging on other mineral bioavailability is largely undocumented, although hypochlorhydria could reduce the bioavailability of some minerals. Finally, the effect of aging on water absorption in the GIT is unknown, although potential changes in tight junctions, transporters, and aquaporins could be involved. 14

Liver system

The aging liver undergoes significant morphological and molecular changes impacting its function and contributing to age-related liver diseases. Key observations include:

• Reduced Liver Volume: Liver volume decreases by 20-40% in the elderly, more significantly in women.

• Hepatocyte Changes: Older hepatocytes exhibit increased ploidy (number of chromosome sets), a decrease in the number but an increase in the volume of mitochondria (though functional impairment isn't fully established), and increased accumulation of secondary lysosomes and lipofuscin. Lipofuscin, associated with oxidative stress and impaired protein degradation, may interfere with cellular processes. Vacuolation of hepatocyte nuclei and increased nuclear size are also observed and linked to cellular senescence (aging at the cellular level), marked by markers like p21 and γH2AX.

• Cellular Senescence and HCC: Cellular senescence, characterized by the aberrant activation of oncogenes, can lead to the secretion of cytokines and chemokines by pre-malignant hepatocytes. While this might trigger immune-mediated clearance, impaired immune surveillance in the elderly increases the risk of hepatocellular carcinoma (HCC) development.

• Role of Resistin: The adipokine resistin, linked to insulin resistance, induces senescence-associated β-galactosidase in hepatocytes by inhibiting sirtuin 1, a crucial regulator of aging.

Aging significantly alters liver blood flow, function, drug metabolism, regeneration capacity, and immune responses. Here's a summary of the key age-related changes:

Blood Flow: Liver blood flow decreases by 35-50% in the elderly, potentially contributing to reduced liver volume.

Liver Function Tests: While liver function is relatively well-preserved overall, some changes occur. Hepatic enzymes and HDL cholesterol are generally maintained, but bilirubin levels may decline due to reduced muscle mass and hemoglobin. Modest decreases in albumin and γ-glutamyl transpeptidase, and increases in bilirubin, have been observed in some studies after adjusting for other factors. Alanine aminotransferase (ALT) levels tend to decrease with age, independent of metabolic syndrome components.

Drug Metabolism: Phase I hepatic drug metabolism is reduced in the elderly, likely due to decreased liver volume and blood flow. This reduction, possibly up to 30% after age 70, is also influenced by a decline in cytochrome P450 activity.

Liver Regeneration: The liver's regenerative capacity declines with age, possibly due to decreased circulating epidermal growth factor (EGF), reduced responsiveness of hepatocytes to EGF, and inhibition of cyclin-dependent kinases by Bim protein. Telomere shortening in aged livers is also observed, particularly in those with liver disease.

Immune System: Both innate and adaptive immunity are impaired with age. Innate immunity shows decreased function in monocytes/macrophages and natural killer (NK) cells. Dendritic cell (DC) function is altered, potentially leading to an imbalance between tolerogenic and immunogenic responses and increased susceptibility to autoimmune diseases. Adaptive immunity is characterized

by reduced T cell numbers and diversity, impaired T cell function (including decreased CD28 expression and Treg function), and decreased B cell numbers and antibody diversity. While responses to foreign antigens and malignant cells are weakened, the risk of autoimmunity may increase due to decreased Treg function and impaired DC maturation.15

Endocrine system

Aging significantly alters the hypothalamic-pituitary axis, impacting hormone secretion and feedback sensitivity. This, coupled with impaired glucose homeostasis, contributes to age-related changes like bone and muscle loss, and increased fat mass. These effects are further complicated by confounding factors such as chronic diseases, inflammation, and poor nutrition. While traditionally viewed as detrimental, leading to hormone replacement therapy proposals, some age-related hormonal changes may be beneficial adaptations.16

The pituitary gland, the "master gland," produces and regulates numerous hormones. Its anterior portion secretes growth hormone (somatotropin), crucial for bone, muscle, and organ growth. Somatotropin secretion peaks during puberty, then declines from around age 25-30, a process called somatopause. This decline, halving roughly every seven years in men, leads to reduced protein synthesis, lean body mass loss (with consequent metabolic rate decrease), increased fat deposition (especially abdominal), bone loss (osteoporosis risk), and weakened immunity. Lifestyle factors (sedentary behavior, high body fat) accelerate somatopause, while estrogen in pre-menopausal women may slow it. While the exact causes remain unclear, the decline mirrors reduced growth hormone-releasing hormone (GHRH) from the hypothalamus. Growth hormone replacement therapy shows promise in reversing some negative effects of somatopause, improving muscle mass and quality of life in clinical trials.

The pea-sized pineal gland, located in the brain's diencephalon, produces melatonin from serotonin, acting as an internal clock. Melatonin secretion is inhibited by light, increasing as light diminishes, preparing the body for sleep. Aging causes pineal gland calcification and a progressive decline in melatonin levels (80% less in 60-year-olds compared to teenagers). Certain medications (beta-blockers, NSAIDs) further reduce melatonin. Lower melatonin is linked to increased sleep disturbances and potentially geriatric insomnia, impacting cognitive function. Morning bright light exposure may improve sleep onset by advancing evening melatonin release. Therapeutic melatonin has shown benefits in improving sleep onset, quality, alertness, and quality of life in older adults with insomnia.

The thyroid gland is crucial for metabolism and calcium regulation, secreting T4 and T3 hormones that control cellular metabolism. While T4 levels remain relatively constant with age due to a balance between decreased secretion and liver clearance, T3 and TSH levels decline, contributing to reduced basal metabolic rate. Autoimmune reactions against the thyroid are common in older adults, potentially leading to autoimmune hypothyroidism (more prevalent in women), characterized by low metabolic rate, weight gain, and low body temperature. Interpreting thyroid function tests in older adults requires caution, as various factors (chronic diseases, dieting, medications) can mimic hypothyroidism (non-thyroidal illness). Regarding calcium homeostasis, the thyroid releases calcitonin, inhibiting bone breakdown. Studies on age-related calcitonin changes are conflicting, with some showing a decline and others finding no age-related decrease.

The four tiny parathyroid glands, located behind the thyroid, release parathyroid hormone (PTH) when blood calcium levels drop. PTH mobilizes calcium from bones (via osteoclasts) to maintain normal calcium levels crucial for various bodily functions. Studies show that circulating PTH levels significantly increase with age in most people (hyperparathyroidism), potentially a major contributor to age-related bone density loss. Recent research also suggests a possible link between elevated PTH and age-related cognitive decline/dementia.

The pancreas's islets of Langerhans regulate blood glucose via insulin secretion from beta cells. Aging is a risk factor for type 2 diabetes, due to reduced insulin sensitivity (fewer cell receptors), leading to increased blood glucose. Fasting blood glucose rises with age (approximately 0.15 mmol/L per decade after age 20). Older beta cells are less responsive to glucose, requiring higher levels to trigger insulin release. The pancreas compensates by producing more insulin (hyperinsulinaemia), but beta cell exhaustion and depletion (due to apoptosis and reduced cell production) eventually decrease insulin secretion (0.5% per year). Increased liver insulin clearance further reduces available insulin. These age-related changes contribute to a diabetogenic environment, increasing type 2 diabetes risk.

Abdominal fat accumulation is common with aging, especially in those with poor diets and sedentary lifestyles. Multiple age-related endocrine changes contribute, including somatopause, autoimmune hypothyroidism, insulin resistance, and reduced sex hormones. This abdominal fat is linked to heart disease, high blood pressure, and type 2 diabetes, often presenting together as metabolic syndrome.

The adrenal glands, located above the kidneys, consist of the medulla (inner) and cortex (outer). The medulla's chromaffin cells secrete adrenaline and noradrenaline ("fight or flight" hormones), causing increased heart rate, blood pressure, blood flow to muscles and brain, pupil dilation, and breathing rate. Adrenaline secretion declines with age, but plasma levels remain relatively constant due to reduced kidney clearance. Older men may show a reduced adrenaline response to stress. The cortex synthesizes steroidal hormones, primarily aldosterone and cortisol.

Aldosterone, a mineralocorticoid, regulates sodium and potassium levels, impacting water balance and blood pressure. Studies show age-related decreases in serum aldosterone, reducing sodium retention. This may contribute to postural hypotension (lightheadedness upon standing), as evidenced by lower aldosterone levels in upright versus recumbent older individuals. Lower sodium levels (hyponatremia) decrease blood volume and pressure. Many medications commonly used in older adults can worsen hyponatremia. Age-related increases in atrial natriuretic hormone (ANH), a diuretic, further reduce blood volume and pressure.

Cortisol, a glucocorticoid, is released in response to stressors and plays roles in anti-inflammation and the breakdown of protein and fat. Studies on age-related cortisol changes are conflicting; some show a significant increase (20-50% from ages 20-80), while others show stable or decreased levels. Elevated cortisol is linked to reduced bone density, increased fracture risk, hippocampal atrophy (leading to cognitive decline), memory loss, and sleep disorders.17

Reproductive system

Middle age brings reproductive changes in both men and women, ultimately leading to infertility (though men retain fertility longer). These changes are driven by fluctuations in sex hormones like estrogen, progesterone, and testosterone. Women experience significant physical and psychological symptoms during perimenopause and menopause. Men experience less dramatic changes associated with andropause, including potential erectile dysfunction and decreased libido.

Females

The number of ovarian follicles decreases progressively with age, accelerating in the fourth decade of life. This decline reduces the number and quality of ova and leads to decreased estrogen production, ultimately triggering menopause around age 51. While genetics are a primary determinant of ovarian aging, oxidative stress, apoptosis, and environmental factors also contribute. Premature ovarian failure (POF) can result from surgery, radiation or chemotherapy, autoimmune reactions, or infections (e.g., mumps or cytomegalovirus).

The perimenopause, a transitional phase before menopause, is characterized by fluctuating hormone levels and increasingly irregular menstrual cycles lasting 2-10 years. While fertility remains, conception becomes more difficult. Symptoms, similar to those of menopause, can range from mild to severe and include hot flashes, night sweats, mood swings, and sadness. Menopause is defined as the cessation of menstruation for 12 consecutive months, typically occurring between ages 44 and 56 (average 50.7). Factors causing premature ovarian failure can also lead to early menopause. Postmenopausal women cannot conceive naturally. During perimenopause and menopause, follicle-stimulating hormone (FSH) levels remain high, but are ineffective in stimulating follicle development, leading to decreased estrogen and infertility. Luteinizing hormone levels are also often elevated but without mature follicles, ovulation cannot occur.

The menopausal transition, involving fluctuating estrogen and progesterone, leads to diverse symptoms. Common symptoms include hot flashes (experienced by most women, potentially due to increased FSH and decreased estrogen affecting the hypothalamus), vaginal atrophy and dryness (due to estrogen decline, causing thinning, reduced lubrication, and increased infection risk), mood changes (possibly linked to hormonal fluctuations, though clinical depression isn't a normal consequence, although prior history increases risk), and sleep disturbances (potentially related to hot flashes, anxiety, depression, and sexual dysfunction, though studies have conflicting results). Decreased bone health, with up to 15% bone mass loss, is also a significant consequence of reduced estrogen, increasing fracture risk and contributing to spinal curvature in some postmenopausal women.

Aging causes shrinkage and loss of ciliated epithelia and mucosa in the fallopian tubes, impacting fertility and increasing the risk of ectopic pregnancy. In the uterus, decreased estrogen production compromises endometrial rebuilding, eventually leading to the cessation of menstruation. The myometrium (smooth muscle layer) shrinks due to reduced estrogen, although the mechanisms aren't fully understood. The perimetrium shows minimal age-related changes. The cervix experiences a reduction in mucus production, further contributing to decreased fertility. These changes collectively contribute to age-related infertility.

Males

Aging in men is associated with a decrease in testicular mass, leading to reduced testosterone and sperm production. While sperm production remains high enough to maintain fertility into advanced age for most men, erectile dysfunction (ED) becomes more prevalent. Sperm ducts lose elasticity with age. Seminal vesicle and prostate gland secretions decrease, reducing ejaculate volume, but sperm concentration remains relatively stable. Decreased prostate secretions may increase urinary tract infection risk. Benign prostatic hyperplasia (BPH) is a common age-related issue causing urination difficulties. The andropause, a gradual decline in testosterone starting in the 30s, is associated with various physical and psychological changes, including increased body fat, reduced muscle and bone mass, ED, reduced libido, increased risk of anemia, memory problems, mood changes (sadness, irritability), hair loss, lethargy, and decreased endurance. Reduced testosterone can also lead to penile shrinkage and erectile dysfunction. Risk factors for ED include smoking and pre-existing conditions like diabetes and cardiovascular disease. Treatments for ED include counseling and medications like sildenafil.

Hormone replacement therapy (HRT) can alleviate some menopausal symptoms in women, including osteoporosis, muscle weakness, vaginal dryness, hot flashes, sleep disturbances, headaches, memory problems, and panic attacks. However, HRT, particularly estrogen plus progesterone, increases the risk of breast cancer. Other risks are less clear. In men, testosterone replacement therapy (TRT) shows some positive effects but carries risks like oily skin, acne, increased hematocrit, gynecomastia, and increased prostate cancer risk. The impact on cardiovascular health remains uncertain.

While aging of the reproductive system is inevitable, certain lifestyle factors can influence the timing and severity of menopause and andropause. Smoking is a major modifiable risk factor, increasing the risk of infertility and early menopause in women and ED, reduced sperm count and quality in men. Low BMI and undernutrition are linked to earlier menopause onset, while the effect of high BMI is less clear—some studies suggest later onset, others no effect, but high BMI/obesity is associated with more severe menopausal symptoms. In men, high BMI is associated with lower testosterone levels, worsening andropause effects.18

Nervous system

The nervous system controls all body organs and tissues, receiving sensory input and responding through effectors. The brain, with its 100 billion interconnected neurons, is complex and its aging is not fully understood. Age-related changes in the brain, spinal cord, and peripheral nerves cause a gradual decline in cognitive function and other issues (e.g., reduced bladder control, postural hypotension), though the brain usually functions adequately throughout life. The aging brain loses neurons and glial cells (0.1% per year between 20-60, accelerating thereafter), resulting in an 11% brain mass reduction by age 90. The remaining tissue accumulates harmful substances (iron, aluminum, free radicals) and pigments (lipofuscin and neuromelanin). Lipofuscin is linked to amyloid protein deposition and neurofibrillary tangles, which are present at low levels in healthy aging brains but high levels in Alzheimer's disease.

The cerebral cortex shows the most neuron loss, with deeper sulci in older brains. While initially thought to affect frontal lobes most, similar losses occur in other cortical regions (e.g., parietal lobes). Structural changes in frontal and parietal lobes correlate with memory impairment;

however, the role of amyloid protein deposition in memory loss is debated, with tau protein accumulation potentially being more significant. The hippocampus, crucial for memory and learning, shrinks with age, potentially explaining difficulties in learning new skills. Ventricular volume increases with age (2.9% per year, accelerating after 70), though its cognitive impact is unclear. Cerebral blood flow decreases (0.38% per year, 27% over 70 years), partly due to cardiovascular changes and potentially exacerbated by carotid artery atherosclerosis. The blood-brain barrier (BBB) weakens with age, particularly in the hippocampus, allowing harmful substances to enter and contribute to cognitive decline. Neurotransmitter production declines with age (noradrenaline, glutamate, dopamine, serotonin), with dopamine reduction impacting motor function, learning, and reward processing. L-DOPA can improve learning in older adults. The spinal cord shows increased cholesterol content in animal models, potentially affecting function. Age-related vertebral and disc changes can compress the spinal cord, slowing nerve impulse conduction and reducing muscle strength, increasing injury risk. Autonomic nervous system function declines with age, increasing the risk of postural hypotension.

Aging in the peripheral nervous system involves neuronal "dying back" (axonal shrinkage), mitochondrial loss, and myelin sheath degeneration. This damage may be due to increased pro-inflammatory mediators and the body's reduced ability to clear toxic metabolites. The lack of a blood-brain barrier (BBB) protection in peripheral nerves contributes to this damage. Myelin loss slows nerve impulse conduction (5-10%), which can exacerbate diabetic neuropathy in older adults. Nerve repair is less efficient in older individuals, leading to reduced sensation and motor control.

Aging affects brain function in several ways, even in the absence of disease. Gradual neuron loss, neurotransmitter depletion, and slower nerve conduction lead to slower information processing, resulting in longer task completion times. Short-term and episodic memory decline is often an early sign of aging, though it doesn't typically impair daily life skills. Verbal skills generally remain strong, but word recall may become more challenging after 70. Reaction time slows due to neuron loss and reduced impulse velocity. Depression is more prevalent in older adults, potentially linked to decreased serotonin levels. However, older adults tend to experience fewer emotional outbursts, possibly due to the relative stability of emotion-related brain regions. Finally, neuroactive drugs can be more potent in older adults due to reduced neural mass, requiring dose adjustments.

Differentiating normal age-related brain changes from those associated with dementia (like Alzheimer's) is challenging because some hallmarks of Alzheimer's—episodic memory loss, brain tissue loss, and amyloid deposition—also occur in healthy older adults. However, advanced age is a major risk factor for dementia. The brain possesses "brain reserve" (physical resources like neuron count and brain mass) and "cognitive reserve" (efficient use of brain resources). High cognitive reserve, associated with factors like high education, IQ, complex occupation, and social interaction, allows for better cognitive function despite brain atrophy. Neural compensation, where new neural circuits take over for damaged ones, also contributes to maintaining cognition. Maintaining mental activity throughout life, through social, physical, and mentally stimulating activities, helps mitigate age-related cognitive decline. Confusion, dementia, and delirium are not inevitable consequences of aging; the brain's redundancy allows for adaptation to age-related changes.19

Musculoskeletal system

Aging significantly impacts skeletal muscle, leading to sarcopenia (age-related muscle loss). Key changes include:

• Muscle Atrophy and Decreased Mass: Muscles atrophy, reducing mass, strength, and contraction speed. This leads to decreased physical strength and difficulty performing daily activities. The decline accelerates after age 60, resulting in significant muscle loss in later life.

• Fiber Type Changes: Sarcopenia primarily affects fast-twitch muscle fibers (used in short bursts of activity), while slow-twitch fibers (used for endurance) are less affected. Slow-twitch fibers may even increase the concentration of some metabolic enzymes, possibly to compensate for the reduced fast-twitch fiber activity.

• Neuromuscular Junction Degeneration: Loss of motor neuron fibers and degeneration of neuromuscular junctions contribute to muscle loss by reducing muscle stimulation.

• Hormonal Changes: Reduced levels of anabolic hormones (growth hormone, testosterone) from middle age onward exacerbate sarcopenia.

• Metabolic Impact: Sarcopenia significantly contributes to the age-related decrease in metabolic rate, increasing the risk of excess calorie storage as fat, particularly in insulin-resistant individuals.

• Skeletal and Joint Support: Muscle mass loss reduces support for bones and joints, contributing to postural changes, increased risk of osteoarthritis, falls, and fractures.

• Impaired Repair and Recovery: Aged muscles are more prone to injury and slower to repair, potentially due to reduced numbers of muscle progenitor cells and cellular senescence.

Aging significantly alters bone structure and metabolism, increasing the risk of osteoporosis and fractures. Key changes include:

• Bone Composition: Bone is composed of inorganic calcium phosphate (hydroxyapatite) and organic type 1 collagen. Calcium phosphate provides rigidity, while collagen provides structural integrity.

• Calcium and Vitamin D: Reduced calcium absorption in the gut and decreased vitamin D levels in older adults reduce calcium availability for bone, contributing to decreased bone density and increased fracture risk.

• Bone Remodeling: Bone is a dynamic tissue constantly undergoing remodeling through the actions of osteoblasts (bone-forming cells) and osteoclasts (bone-resorbing cells).

• Osteoblast Activity: Osteoblast activity is stimulated by physical stress and weight-bearing activity. Inactivity, coupled with age-related muscle loss, reduces osteoblast activity, leading to decreased bone density.

• Decalcification: The age-related loss of skeletal muscle mass further reduces the load on bones, exacerbating decalcification. Maintaining mobility and activity is crucial for mitigating bone loss in older adults.

Bone density peaks around age 30 in both men and women, with approximately 90% of peak bone mass achieved by age 20 in men and 18 in women. After age 30, bone density gradually declines. Women experience significantly greater bone loss than men, particularly after menopause due to the loss of estrogen's protective effects. This bone loss continues throughout aging, resulting in approximately half the bone mass by age 80 compared to peak bone mass.

Osteoporosis, characterized by porous and weakened bones, has two main types: Type I, primarily affecting postmenopausal women due to estrogen deficiency, and Type II (senile osteoporosis), affecting both sexes due to reduced osteoblast activity and increased pro-inflammatory cytokines like interleukin-6. Vertebrae are especially vulnerable, leading to compression fractures and spinal curvature. Several factors contribute to age-related bone loss and osteoporosis, including hormonal changes (reduced estrogen/testosterone, growth hormone), decreased body weight and physical activity, lower calcium and vitamin D levels, increased parathyroid hormone, and smoking.

Age-related bone density loss significantly increases fracture risk in various bones, including the femur, ribs, vertebrae, and upper/lower arm bones. This risk is heightened by reduced collagen content and structural changes, compromising bone integrity. Immobility, such as prolonged hospitalization, further exacerbates fracture risk. Fracture healing is also slower in older adults. Studies indicate a high prevalence of femoral neck osteoporosis (around 5% in adults over 50 in the US), a region particularly vulnerable to potentially life-threatening fractures, with increasing frequency after age 60 and higher incidence in women.

Articular cartilage in synovial joints acts as a shock absorber and facilitates smooth bone movement. Age-related decline in chondrocyte (cartilage-forming cell) number and activity leads to cartilage reduction in key joints like the knees. This cartilage loss increases susceptibility to joint damage and painful bone-on-bone contact, a hallmark of osteoarthritis.

Osteoarthritis, the most prevalent joint disorder globally, significantly impacts older adults. Studies reveal high rates of symptomatic knee osteoarthritis in individuals over 60 (around 10% of men and 13% of women in the US). This condition places a substantial burden on healthcare systems due to the need for joint replacement surgeries. Age-related changes in joint ligaments, specifically the decline in collagen and elastin, contribute to decreased elasticity, stiffness, and reduced mobility. This effect is particularly pronounced in certain joints, such as ankles in women aged 55-85, who can experience up to a 50% loss of flexibility. While other risk factors exist (genetics, gender, obesity, prior injury), age remains the most significant factor in osteoarthritis development.

Musculoskeletal aging is influenced by genetics, environment, and lifestyle, leading to individual variations in the aging process. Maintaining the structural and functional integrity of the musculoskeletal system is crucial for overall health and delaying the onset of frailty.

Programmed cell death (apoptosis) contributes to bone loss and sarcopenia. Exercise, caloric restriction, and antioxidants (carotenoids, oleic acid) may mitigate apoptosis. Caloric restriction can slow or reverse age-related neuromuscular junction changes, potentially reducing sarcopenia. Drugs like metformin and resveratrol, mimicking the effects of caloric restriction and exercise, show promise in animal studies as alternatives to dietary restriction.

Increasing calcium, vitamin D, and lean protein intake can improve bone density and support muscle growth, potentially counteracting age-related declines in nutrient absorption. While increased protein intake enhances muscle protein synthesis in younger adults, this effect is less pronounced in older individuals. Studies show that creatinine supplementation can increase muscle

strength and performance, and protein drinks with β-alanine improve muscle capacity and quality in older adults.

Hormone replacement therapy (HRT), including estrogen replacement therapy (ERT) for women and testosterone replacement therapy (TRT) for men, effectively improves bone health by increasing bone density and reducing fracture risk. While TRT enhances lean muscle mass and counteracts some age-related muscle changes in men, the anabolic effects of HRT in women are less established. Although women can use TRT, potential side effects like increased hair growth and voice changes may deter them.

Muscle disuse leads to atrophy. Regular, moderate exercise maintains lean muscle mass, increases bone density, reduces fat, and enhances mitochondrial function for improved energy metabolism and muscle power. Mitochondrial energy efficiency can be maintained until at least age 75 with consistent physical activity. Progressive resistance training is highly effective for increasing bone density and muscle growth in older adults with sarcopenia. Even a single weekly exercise class combined with home exercise can significantly improve muscle strength, reversing age-related decline. The key to musculoskeletal health is consistent use and activity.20

Immune system

Immunosenescence, the age-related decline in immune function, increases susceptibility to infections, autoimmune diseases, and cancer. It involves complex changes in both innate and adaptive immunity, leading to immunodeficiency. Inflammaging, a chronic, low-grade inflammation characterized by increased pro-inflammatory cytokines (IL-1, IL-6, TNF-α) and decreased anti-inflammatory cytokines (IL-10, TGF-β), is associated with immunosenescence. While initially viewed as harmful, recent research suggests inflammaging may correlate with longevity, possibly representing an optimization of resources in the aging body. Thymic involution, reducing the T-cell receptor repertoire, might also contribute to lower energy consumption, supporting other bodily functions. The relationship between immunosenescence and inflammaging may be viewed as two sides of the same coin, crucial for human longevity despite ultimately contributing to age-related pathologies and mortality. An alternative perspective suggests immunosenescence reflects a decline in adaptive immunity, while inflammaging reflects activation of innate immunity. 21

Age-related immune decline (immunosenescence) is influenced by various extrinsic factors. Stress, through activation of the HPA and SAM axes, impairs immune responses, increasing susceptibility to infections and cancer. Cortisol, released during stress, may increase T-cell apoptosis. Sleep disturbances are also associated with immune dysfunction, marked by altered cytokine levels and metabolic changes. In contrast, moderate physical activity enhances immune function by modulating cytokine production, improving NK and T-cell activity, and boosting antibody responses. Nutrition plays a crucial role; protein-energy malnutrition is common in the elderly and impairs immunity. Lipid composition of cell membranes influences cell function and response to free radicals, with eicosapentaenoic acid (EPA) showing potential benefits. The complex interplay between nutrition, immune function, and infection makes it challenging to quantify their relationships. Immunosenescence is characterized by a paradoxical combination of hyperactivation (inflammaging) and dysfunction of the immune system, largely due to thymic involution and

chronic antigenic exposure. Understanding these factors is crucial for developing effective interventions to improve the health and longevity of the aging population.22

Visual system

Age-related vision decline stems from both anatomical changes in the eyeball and reduced computational efficiency in higher-level visual processing. Anatomical changes include increased lens weight and thickness, leading to reduced elasticity and presbyopia (difficulty focusing on near objects). The ciliary muscle, responsible for lens shape adjustment, also diminishes in diameter with age. Furthermore, ocular aberrations increase with age, primarily due to a loss of compensation between corneal and internal aberrations, resulting in poorer image quality. This reduced image quality contributes to decreased contrast sensitivity, although neural mechanisms also play a role. In essence, aging vision is a complex process involving both structural and functional decline within the visual system.

Age-related vision decline affects multiple visual functions, as demonstrated by large-scale studies like the Salisbury Eye Evaluation project. These declines include decreased visual acuity, contrast sensitivity, glare sensitivity, and visual field size, all of which worsen linearly with age. High-contrast acuity remains relatively stable until the 60s and 70s, while other visual functions decline earlier. Studies suggest that reduced contrast sensitivity in older adults is primarily due to increased internal noise rather than impaired external noise filtering. The impact of aging on contrast sensitivity is more pronounced at lower luminance levels, indicating a contribution from neural mechanisms beyond purely optical factors. Temporal flicker also differentially affects contrast sensitivity across age groups, further supporting the involvement of neural processing changes. Egocentric distance judgment shows age-related differences, potentially due to accumulated real-world experience. Motion perception is also impaired with age, with higher thresholds for low-speed motion detection and speed discrimination. However, older adults may show higher sensitivity to high-contrast, large-size motion stimuli, possibly due to reduced center-surround antagonism in neural processing. The varied effects of aging on motion perception highlight the complexity of the underlying mechanisms. Finally, studies show a strong correlation between visual field loss (especially in the inferior region and central vision) and increased fall risk in older adults.

The decline in visual function among older adults significantly increases their risk of falls. This correlation is supported by large-scale studies like the Blue Mountain Eye Study, which linked reduced visual acuity, contrast sensitivity, glare sensitivity, and visual field size to a higher fall risk. The presence of eye diseases such as cataracts and glaucoma further exacerbates this risk.

Reduced visual acuity, a common age-related impairment, is frequently associated with increased fall risk, although some studies show inconsistent results, possibly due to variations in visual acuity testing methods. Low visual acuity may weaken the vestibulo-ocular reflex, impacting balance control.

Low contrast sensitivity, even with good visual acuity, makes it harder to detect hazards, particularly in low-light conditions. Studies using tests like the contrast sensitivity function and the Melbourne Edge Test consistently demonstrate a link between poor contrast sensitivity and falls, both past and future occurrences. This correlation extends to performance on physical tasks related

to fall risk, such as stand-to-sit and reaction time tests. In short, both reduced visual acuity and contrast sensitivity are significant risk factors for falls in older adults.

Impaired depth perception (stereoacuity) and reduced visual field size are strongly linked to increased fall risk in older adults. Poor stereoacuity, measured by tests like the Howard-Dolman and Frisby Stereo tests, is more strongly correlated with falls than visual acuity or contrast sensitivity. This is further supported by findings that monocular vision and disparities in visual acuity between the two eyes increase fall risk. Reduced visual field size, particularly in the inferior region, is also a significant risk factor for falls. Studies consistently show that visual field impairment, especially severe binocular loss, is associated with a higher incidence of falls. The inferior visual field's importance in real-world navigation and postural stability contributes to this correlation. Impairment in both central and peripheral vision increases fall risk, with the impact possibly linked to the number of neurons in the primary visual cortex stimulated by the visual field.

Vection, the illusory sensation of self-motion induced by visual motion stimuli, demonstrates a direct link between visual motion perception and postural balance. The magnitude of vection is influenced by several factors, including visual field size; peripheral vision is crucial for inducing vection, particularly circular and roll vection. The presence of stationary objects, especially those further away than the moving stimuli, reduces vection.

Vection and postural sway are strongly correlated. Optic flow, which generates vection, also induces postural sway. The magnitude of vection in various directions (depth, roll) is positively correlated with the amount of postural sway. Dependence on vision for postural control predicts the strength of vection. Even illusory visual motion, as in the motion aftereffect (MAE), can induce postural sway.

With age, perceived vection decreases while postural sway increases. This discrepancy may be due to age-related reduction in proprioceptive feedback. Further investigation into the visual cue components of visual motion stimulation is vital for understanding age-related fall risk.23

Auditory system

Aging causes hearing deterioration, impacting speech comprehension, especially in noisy environments. This isn't solely due to peripheral issues like hair cell loss and stria vascularis dysfunction; the central auditory system also undergoes significant age-related changes. Studies in animal models, often using immunocytochemical techniques targeting specific markers (GAD, parvalbumin, calbindin, calretinin), reveal alterations in neuron numbers and function. Human studies show gray and white matter atrophy, cerebrospinal fluid space enlargement, altered metabolite levels (as seen via magnetic resonance spectroscopy), and different activation patterns in functional magnetic resonance imaging (fMRI) studies. These central auditory system changes, largely independent of inner ear issues, contribute significantly to central presbycusis.24

Skin

Aging skin undergoes physiological changes including impaired barrier function, decreased epidermal turnover, structural impairment, and reduced vascularity, particularly around hair follicles and sweat glands. Environmental factors like sun exposure and chemical agents accelerate this process. While aging skin continues to perform essential functions like protection, absorption, secretion, excretion, thermoregulation, pigmentation, accumulation, sensory perception, and immunity, its efficiency decreases with age.25

Osteopathic medicine

Osteopathic medicine is a holistic approach to healthcare that integrates conventional medical practices with a philosophy emphasizing the interconnectedness of body structure and function, and the body's inherent ability to heal. This philosophy rests on three core principles: the body is a unified system, it possesses self-healing mechanisms, and structure and function are mutually influential. Treatment considers these principles to promote the body's natural healing processes.26

The main osteopathic treatment techniques include: 1. Muscle Energy Techniques, 2. Myofascial Release Technique, 3. Balanced Ligamentous Tension Technique, 4. Diaphragm Treatment Technique, 5. High-Velocity Low-Amplitude Technique, 6. Rib Raising Technique, 7. Lymphatic Pumping Technique, and 8. Cranial Osteopathy.27

Effectiveness of Osteopathic medicine in elderly (or geriatric patients)

Osteopathic medicine, with its distinctive philosophy and principles, can provide unique and beneficial approaches for geriatric patients who require special considerations for certain aspects of their medical care. Changes in anatomy and physiology that occur with aging, the psychosocial aspects of aging, and the potential for age- related diseases dictate that geriatric patients cannot simply be considered older adults. Medical care of geriatric patients is a multidisciplinary and holistic endeavor, with the ultimate goal of assisting these patients in maintaining optimum health and function. 26

Falls in elderly

Falls are a major cause of death and disability in the elderly, with incidence increasing with age. A significant percentage of older adults experience falls annually, leading to numerous emergency room visits. Falls result from a combination of intrinsic (individual) and extrinsic (environmental) factors.

Intrinsic risk factors include a history of falls, age, gender (women more prone), race (Whites more prone), polypharmacy (especially benzodiazepines), solitary living, various medical conditions (vascular disease, arthritis, thyroid dysfunction, diabetes, depression, COPD, vertigo, incontinence), impaired gait and mobility, deconditioning, fear of falling, poor nutrition (including vitamin D deficiency), cognitive disorders (dementia), and impaired vision (e.g., glaucoma, cataracts). Foot problems also contribute significantly.

Extrinsic risk factors encompass environmental hazards such as poor lighting, uneven surfaces, and slippery floors. These environmental factors account for a substantial portion of falls.28,29

In 2011, A pilot study of 40 healthy elderly patients (65+) examined the effects of a weekly osteopathic manipulative treatment (OMT) protocol. The OMT protocol included various soft tissue and myofascial release techniques, cervical spine manipulation, cranial techniques (occipitoatlantal and condylar decompression, venous sinus technique, V-spread, frontal and parietal lifts, CV4 technique), targeting areas believed to influence balance and postural stability. The study suggested that this cranial manipulation protocol may improve vestibular balance control structures and postural stability in healthy older adults.30

Gilliss et al., reported A 65-year-old man with multiple sclerosis and gait dysfunction (compensated Trendelenburg gait) was treated with osteopathic manipulative treatment (OMT). Biomechanical examination revealed right-on-right sacral torsion and left innominate posterior rotation. After OMT, gait analysis showed significant improvements: a 58% reduction in steps taken, improved step and stride length, increased velocity, and restored stride-length symmetry. This case suggests that somatic dysfunction, specifically sacroiliac joint dysfunction, may contribute to a Trendelenburg gait, traditionally attributed to hip abductor weakness, and that OMT can be effective in correcting this gait pattern.31

The systematic review by Veloso, Carolina Fantinel, et al., analyzed six studies (2009–2015) from various countries investigating the effects of osteopathic manipulation on postural balance. The studies utilized different osteopathic techniques and balance assessment tools, including force platform, baropodometry, the Dizziness Handicap Inventory (DHI), and computerized dynamic posturography. The review concluded that osteopathic manipulation was effective in improving postural balance across all included studies.32

Vertigo

The study by Fraix and Marcel aimed to investigate the safety and feasibility of osteopathic manipulative treatment (OMT) for chronic benign paroxysmal positional vertigo (BPPV) lasting over 3 months. The rationale is that cervical spine dysfunction can contribute to vertigo, and OMT addresses somatic dysfunction (restricted joint movement and soft tissue changes). This pilot study, using the Dizziness Handicap Inventory (DHI) as a validated outcome measure, is the first to explore OMT's efficacy in vertigo treatment. The study focuses on chronic BPPV (lasting >3 months) because spontaneous remission typically occurs within a shorter timeframe. The researchers hypothesize that OMT may reduce vertigo symptoms by addressing underlying cervical spine somatic dysfunction.

This pilot study of evaluated the safety and feasibility of osteopathic manipulative treatment (OMT) for patients with chronic benign paroxysmal positional vertigo (BPPV). Eighteen patients completed the study. All participants met inclusion criteria. Sixteen patients (88.9%) completed the OMT treatment course. Significant improvement ($p < .001$) was observed in Dizziness Handicap Inventory (DHI) scores after treatment. While some patients experienced mild, transient adverse effects (vertigo exacerbation or muscle soreness), OMT was generally well-tolerated. The study concludes that OMT is a feasible treatment option for vertigo and warrants further investigation in a randomized controlled trial.33

Hypertension

Hypertension in older adults significantly increases the risk of adverse cardiovascular events like heart failure, stroke, and death. The global prevalence of hypertension is rising due to an aging population and increased obesity, projected to affect one-third of the world's population by 2025. Older adults face additional challenges due to age-related changes in hemodynamics, arterial stiffness, and declining renal function. Management requires individualized approaches considering frailty, comorbidities, and psychosocial factors. Lifestyle interventions are crucial for prevention and as adjunctive therapy to reduce medication needs. Pharmacological treatments, including diuretics, renin-angiotensin system blockers, and calcium channel blockers, have shown benefits. Addressing lifestyle changes in younger generations is vital to mitigate the future economic and public health burden of hypertension.34

The Italian study investigated the effectiveness of osteopathic manipulative therapy (OMT) as a complementary treatment for hypertension. Sixty-three hypertensive patients were divided into an OMT group and a control group (standard care only); assignment wasn't randomized. Both groups received conventional antihypertensive medication. After 12 months, multivariate analysis showed that the OMT group had significant improvements in intima-media thickness (IMT) and systolic blood pressure (SBP) compared to the control group. Univariate analysis also showed improvements in IMT, BMI, SBP, DBP, and reduced medication dosage in the OMT group. While the study had limitations (small sample size, non-random assignment), the findings suggest OMT may be a beneficial adjunctive therapy for hypertension, potentially by reducing inflammation and improving autonomic nervous system function. The study's positive results, despite limitations, warrant further research, particularly larger randomized controlled trials.35

In 2018,The study compared blood pressure (BP) and heart rate variability (HRV) responses to the CV4 osteopathic technique in hypertensive (HT) and normotensive (NT) men (ages 40-60). BP was measured before and after CV4, and at 5, 10, and 15 minutes post-intervention. HRV parameters were also analyzed. Results showed a significant BP reduction in the HT group 15 minutes post-CV4. Both groups demonstrated increased parasympathetic activity (increased high-frequency HRV) and decreased sympathetic activity (attenuated low-frequency HRV). The findings suggest that CV4 may shift the autonomic balance, but further research is needed to understand the mechanism of BP reduction.36

Peripheral arterial disease (PAD)

Peripheral arterial disease (PAD) is prevalent in the elderly, causing symptoms like intermittent claudication (IC). Management focuses on preventing cardiovascular events and relieving symptoms. Cardiovascular event prevention prioritizes smoking cessation, exercise, antiplatelet therapy, and managing dyslipidemia, hypertension, and diabetes. Exercise improves walking ability. While drug treatments for IC have shown mixed results, statins and cilostazol (a phosphodiesterase 3 inhibitor) offer some benefit, with cilostazol notably increasing maximum walking distance. Cilostazol's safety profile is generally acceptable, though its mechanism isn't fully understood. For patients with disabling IC, cilostazol should be considered alongside risk factor management.37

The study by Lombardini, Rita, et al. examined the effects of osteopathic manipulative treatment (OMT) on peripheral arterial disease (PAD) patients with intermittent claudication. Fifteen patients receiving OMT were compared to a matched control group. The OMT group showed significant improvements in brachial flow-mediated vasodilation (a measure of endothelial function), ankle-brachial pressure index, treadmill test performance, and quality of life compared to the control group. Univariate analysis in the OMT group revealed a negative correlation between changes in brachial flow-mediated vasodilation and IL-6 levels (an inflammatory marker), and a positive correlation between claudication pain time and physical function score. The results suggest that OMT may be a beneficial adjunctive therapy for PAD, improving endothelial function and functional capacity, and potentially offering a valuable alternative or supplement to traditional exercise-based therapies. The small sample size limits the strength of the conclusions, however.38

Pneumonia

Pneumonia is a significant cause of mortality in the elderly due to factors like impaired reflexes, reduced lung function, weakened immunity, and underlying health conditions. Elderly patients are particularly susceptible to aspiration pneumonia due to impaired gag reflexes and neurological disorders. Pre-existing cardiopulmonary disease can worsen pneumonia's impact, potentially leading to congestive heart failure or myocardial infarction. Long-term smokers face increased risk due to potential bronchogenic carcinoma or chronic bronchitis. Impaired splenic function, often associated with age-related systemic disorders, weakens humoral immunity, increasing vulnerability to encapsulated bacteria like Streptococcus pneumoniae and Haemophilus influenzae. While the same bacteria cause pneumonia in both young and old adults, the distribution differs; H. influenzae is more prevalent in the elderly, and Moraxella catarrhalis is significant in those with chronic bronchitis. Atypical pathogens also show age-related differences in prevalence. Pneumonia can be classified by acquisition method (hematogenous, inhalation, aspiration), location (community-acquired, nursing home-acquired, hospital-acquired), or causative organism. The clinical presentation is primarily determined by the organism, not the acquisition location. For example, pneumococcal pneumonia presents similarly regardless of where it's acquired.39

Noll, Donald R., et al. investigated the effect of osteopathic manipulative treatment (OMT) on elderly pneumonia patients. Twenty-one patients over 60 were randomly assigned to an OMT group (11 patients) or a control group (10 patients). Both groups received standard medical care. While the OMT group showed shorter mean durations for leukocytosis, IV antibiotics, and hospital stay, these differences weren't statistically significant. However, the OMT group's mean duration of oral antibiotic use was significantly shorter (3.1 days vs. 0.8 days). The results suggest OMT might reduce antibiotic use and hospital stay in elderly pneumonia patients, but a larger study is needed to confirm these findings.40

Gastroesophageal Reflux Disease (GERD)

Zhu et al. showing a significantly higher prevalence of pathologic gastroesophageal reflux (GER) in elderly individuals (65-76 years old) compared to younger adults (21-64 years old). The study found a substantially greater percentage of time with a 24-hour pH below 4 (indicative of significant acid exposure) in the elderly group. The text concludes that approximately 20% of

individuals over 65 experience GERD, likely due to age-related physiological changes in the esophagus and oropharynx, as well as the presence of other health conditions (comorbidities).41

Räihä, I. J., et al. investigated the prevalence and characteristics of symptomatic gastroesophageal reflux disease (GERD) in elderly individuals (aged 65+) in Turku, Finland. A questionnaire was sent to a stratified random sample of 559 non-institutionalized individuals, with a response rate of 92% (487 usable responses). The questionnaire assessed various GERD symptoms (heartburn, regurgitation, chest pain, etc.). Results showed an age-adjusted prevalence of daily GERD symptoms of 8% in men and 15% in women (statistically significant difference). A higher percentage of both men (54%) and women (66%) reported experiencing symptoms at least monthly. Prevalence remained relatively consistent across different age groups within the elderly population. The study found that typical GERD symptoms often co-occurred with atypical symptoms like chest pain, dyspepsia, or respiratory issues. The conclusion highlights the high prevalence of GERD symptoms in the elderly, with women experiencing them more frequently than men, and the frequent association of typical GERD symptoms with atypical symptoms.42

Eguaras, Nuria, et al. investigated the effectiveness of a specific osteopathic manual technique on Gastroesophageal Reflux Disease (GERD) symptoms. A randomized, double-blind, placebo-controlled trial was conducted with 60 GERD patients, randomly assigned to either an experimental group receiving the osteopathic technique or a control group receiving a sham treatment. The GerdQ questionnaire, cervical range of motion (CROM), and C4 spinous process pressure pain threshold (PPT) were measured before and after treatment. Results showed significant improvement in GERD symptoms one week post-intervention in the experimental group compared to the control group, along with increased cervical mobility and improved C4 PPT. The findings suggest that this osteopathic manual technique may be beneficial in managing GERD symptoms.43

The randomized controlled trial of Lynen, Andreas, et al. investigated the effectiveness of osteopathic treatment for Gastroesophageal Reflux Disease (GERD). Seventy patients were randomly assigned to either an osteopathic treatment group (receiving four treatments over eight weeks) or a control group (receiving no treatment). While the primary outcome measure (Reflux Disease Questionnaire, RDQ) showed statistically significant improvement in the osteopathic group, the data was unreliable due to numerous incorrectly completed questionnaires. However, the secondary outcome measure (Quality of Life in Reflux and Dyspepsia, QUOLRAD) showed a statistically significant improvement in quality of life in the osteopathic group compared to the control group (0.69 [95%CI = 0.35 to 1.0]). This improvement was sustained at 20 weeks. Medication use also decreased significantly in the osteopathic treatment group. The study suggests that osteopathic treatment may be beneficial for GERD, but recommends future studies with longer follow-up periods and a global rating of change measurement to strengthen the conclusions.44

Pain in elderly

Chronic pain significantly impacts a large portion of the population, particularly the elderly, leading to functional disability, psychological disorders (depression and anxiety), cognitive deficits, and sleep disturbances. Common pain sources in the elderly include neurodegenerative and musculoskeletal conditions, peripheral vascular diseases, arthritis, and osteoarthritis. These conditions negatively affect quality of life, leading to social isolation, reduced physical activity, and dependence in daily living. Organ dysfunction and other existing diseases further complicate pain

perception and response in this population. Aging is associated with altered pain processing mechanisms, potentially due to degeneration of pain-modulating circuits. While elderly individuals may have increased pain thresholds and decreased pain sensitivity, they remain at increased risk for dementia and cognitive impairment when experiencing chronic pain. This review aims to summarize current pre-clinical and clinical research on chronic pain in the elderly, focusing on altered mechanisms, comorbidities, challenges, and potential therapeutic approaches.45

This descriptive study in 2021 analyzed electronic health records from 1,238 geriatric patients (over 60 years old) who received Osteopathic Manipulative Treatment (OMT) at an outpatient clinic between 2016 and 2019. The findings reveal that the majority of patients were female (68.7%), primarily covered by Medicare (79.2%), and most commonly presented with back pain (53.3%). Treatment primarily focused on the thoracolumbar region, with Muscle Energy Technique being the most frequently used OMT technique (16.4%). The use of High-Velocity, Low-Amplitude (HVLA) techniques decreased with increasing age. Treatment response was overwhelmingly positive (99.6% improvement). The study concludes that geriatric OMT patients predominantly present with musculoskeletal issues, aligning with national epidemiological data, and that the OMT techniques employed are consistent with national practice.46

Knebl, Janice A., et al. investigated the effectiveness of the Spencer technique (a type of osteopathic manipulative treatment, or OMT) on shoulder range of motion (ROM), physical functioning, and pain in 29 elderly patients. Patients were randomly assigned to either an OMT group or a control group and assessed at baseline and week 19. A double-blind design was used for assessment. Both groups showed significant increases in ROM and decreases in perceived pain over the 19 weeks. However, the OMT group showed significantly greater improvement in active and passive shoulder flexion ROM compared to the control group. The study suggests that the Spencer technique may be beneficial for improving shoulder function in elderly patients.47

In 2018, The rationale is that a significant portion of older cancer patients experience chronic pain, often inadequately managed with pharmacological approaches alone. OMT, a non-pharmacological complementary therapy, has shown promise in reducing pain and inflammation through its effects on the autonomic nervous system and cytokine levels. The study will compare OMT to physiotherapy, a standard of care, to determine if OMT offers a superior or comparable benefit in this specific patient population. The study's importance lies in addressing the growing need for effective, non-pharmacological pain management strategies for the increasing number of older adults with cancer.

In a study by Arienti, Chiara, et al., the effects of osteopathic manipulative treatment (OMT) on pain relief and quality of life were investigated in hospitalized elderly oncology patients. A non-randomized controlled trial compared an OMT group (receiving OMT in addition to physiotherapy) to a control group (receiving physiotherapy only). Twenty-three patients were enrolled (12 in each group). Pain intensity (Numeric Rating Scale, NRS) and quality of life were assessed at baseline and weekly.

The OMT group showed significantly reduced NRS scores at weeks 2 and 4, but the difference in quality of life between the groups at the end of the study was not significant. While the physiotherapy-only group also showed pain reduction at week 4, between-group comparisons revealed no statistically significant differences in NRS or quality of life between the two treatment approaches.

The study concluded that OMT provided significant pain relief in hospitalized elderly oncology patients, although its impact on quality of life was not statistically significant compared to physiotherapy alone.48

Constipation

Chronic constipation (CC) is a prevalent issue among the elderly, impacting their quality of life and often linked to other health problems. Prevalence estimates vary (15-30% in those over 60) due to inconsistent diagnostic criteria. Primary care physicians are key in managing this condition, especially with an aging population. Several factors contribute to CC in the elderly, including physical inactivity, multiple medications (polypharmacy), underlying medical conditions, reduced rectal sensitivity, and defecatory disorders.

Diagnosis involves a thorough medical history (including medication use), digital rectal exam, and potentially blood tests and colonoscopy to rule out organic causes. Physiological tests (anorectal manometry, colonic transit time studies, defecography) can assess bowel function. Treatment is individualized and often starts with lifestyle changes, medication adjustments, and laxatives. Biofeedback is beneficial for defecatory disorders. The approach is stepwise and empirical for chronic idiopathic constipation.49

In a study by Rugman, Rebecca, Kylie Fitzgerald, and Gary Fryer, the effectiveness of osteopathic manipulative treatment (OMT) for chronic constipation was investigated in a small group of six participants (mean age 48.5 years). Participants received six OMT sessions over four weeks. Significant improvements were observed in constipation severity, overall symptoms, colonic transit times, and quality of life (all $p < 0.01$). However, the study's small sample size and lack of a control group limit the generalizability of these findings.50

Functional constipation, a prevalent intestinal motility disorder, is characterized by infrequent bowel movements, straining, hard stools, and a feeling of blockage. Its prevalence varies widely (2.6% to 30.7%), affecting women and older adults disproportionately. Stroke survivors experience a particularly high rate of functional constipation (50% in the first month post-stroke, decreasing to 30% after 36 weeks), regardless of the affected brain hemisphere. Contributing factors include immobility, dehydration, reduced consciousness, impaired colon contractility, medication side effects, and neurological impairment. The condition significantly impacts quality of life, causing abdominal discomfort, pain, and psychological distress. Treatment options range from lifestyle changes (increased water and fiber intake) to laxatives, biofeedback, enemas, and surgery, with existing treatments often proving expensive, invasive, and ineffective long-term.

Osteopathy, a holistic diagnostic and treatment method, uses structural, cranial, and visceral approaches. The visceral approach employs manual techniques to diagnose and correct mechanical, vascular, and neurological bowel dysfunctions, improving bowel function. Osteopathic treatment for constipation is effective because it addresses the loss of resilience in structures surrounding the abdominal organs, restoring organ movement and tissue function.

In a 2020 study by Neto, Hugo Pasin, and Rodolfo A. Borges, the effectiveness of visceral mobilization in treating functional constipation and improving static balance in stroke survivors was investigated. Thirty stroke survivors were randomly assigned to one of two groups: a group receiving conventional physical therapy plus visceral manipulation (including sphincter inhibition

and large intestine mobilization), and a group receiving conventional physical therapy plus a sham procedure. Assessments of intestinal symptoms (using a rating scale) and static balance (using a computerized plantar pressure sensor) were conducted before, immediately after the first session, and one week after five sessions. The group receiving visceral mobilization showed significant improvements in both intestinal symptoms (frequency of bowel movements, abdominal pain, difficulty with elimination, etc.) and static balance (reduced anteroposterior and mediolateral sway). The study concludes that visceral mobilization can be a valuable addition to neurological rehabilitation programs for stroke survivors experiencing constipation.51

COPD

Chronic obstructive pulmonary disease (COPD) is a prevalent, debilitating disease among the elderly, causing significant morbidity and mortality despite being treatable and preventable. Its rising prevalence is linked to the global smoking epidemic, resulting in substantial healthcare costs. COPD has systemic effects, often co-occurring with cardiovascular disease, muscle wasting, osteoporosis, depression, anxiety, and malnutrition. These comorbidities negatively impact quality of life and treatment adherence. Malnutrition is a significant mortality predictor.52

In 2020, Buscemi, Andrea, et al. conducted a randomized controlled pilot study investigating the efficacy of osteopathic manipulative treatment (OMT) in addition to conventional pharmacological treatment for patients with moderate-to-severe chronic obstructive pulmonary disease (COPD). Thirty-two patients were randomized into two groups: a control group receiving only Indacaterol-Glycopyrronium, and an OMT group receiving both pharmacological treatment and OMT targeting various respiratory structures (maxillary sinus, vertebral-pleural ligaments, etc.). The OMT group showed statistically significant improvements in spirometry (FVC and FEV1), COPD Assessment Test (CAT) scores, and six-minute walk test (6MWT) results compared to the control group. These improvements were sustained in the OMT group at a later assessment point. The study concludes that adding OMT to conventional COPD treatment may significantly improve patient quality of life and functional capacity.53

Zanotti, Ercole, et al. compared the effectiveness of pulmonary rehabilitation (PR) alone versus PR combined with osteopathic manipulative treatment (OMT) in patients with severe COPD. Twenty stable COPD patients participated in a four-week, five-days-a-week program. Both groups received PR, but only one group received additional OMT. The primary outcome measure was exercise capacity (6-minute walk test), which improved significantly in both groups, but more so in the group receiving OMT (72.5 meters vs. 23.7 meters improvement). The secondary outcome, pulmonary function, showed a significant reduction in residual volume (RV) only in the OMT group. Additionally, only the OMT group experienced an increase in FEV1. The study concludes that adding OMT to PR may enhance exercise capacity and reduce RV in severely impaired COPD patients.54

Depression

Depression in the elderly is significantly linked to chronic illnesses and cognitive impairment, resulting in suffering, family problems, disability, and increased mortality. The aging process and various diseases (arteriosclerosis, inflammatory, endocrine, and immune changes) damage brain structures (frontostriatal pathways, amygdala, hippocampus), making older adults more prone to depression. Genetic factors may also contribute. Psychosocial stressors (poverty, disability, isolation, relocation, caregiving, bereavement) worsen the situation. While antidepressants are generally well-tolerated and effective in older adults, and evidence-based prevention and treatment guidelines exist, inadequate insurance coverage in places like North America hinders access to these crucial services.55

Miranda, Eneida, et al. investigated the effectiveness of osteopathic manipulative treatment (OMT) as an adjunctive therapy for anxiety and/or depression. Sixteen adult participants (10 control, 6 treatment) with anxiety and/or depression, all taking psychotropic medication, were randomly assigned to either an OMT group or a control group for eight weeks. Weekly anxiety and depression levels were assessed using modified GAD-7 and HANDS scales. The OMT group showed statistically significant improvements in both anxiety and depression scores by weeks 7 and 8, while the control group showed worsening symptoms. The study concludes that OMT may be a beneficial complementary treatment for anxiety and depression.56

Dugailly, Pierre-Michel, et al. investigated the short-term effects of a single osteopathic treatment session on anxiety, body satisfaction, and global self-perception in 34 asymptomatic female volunteers. Participants were randomly assigned to either an osteopathic treatment group (OG) or a control group (restful state). Both groups showed improvements in psychological measures after the 30-minute intervention, but the OG group experienced significantly greater improvements in anxiety and global self-perception compared to the control group. The study suggests that osteopathic treatment may have a positive short-term impact on these psychological factors, warranting further research to confirm these findings and explore the treatment's broader applications.57

Conclusion

Research suggests that the global population is rapidly aging, a trend evident in the Americas, Europe, and Asia. The physiological decline associated with aging contributes to various illnesses and discomfort. Holistic medical approaches, such as osteopathy, have shown promise in treating older adults. However, research on the effectiveness of osteopathic techniques specifically in elderly populations remains limited. Therefore, further research in this area is needed.

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